Visual Acuity During Treadmill Walking

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Background: An awareness of the physical world is essential for successful navigation through the environment. Vision is the means by which this awareness is made possible for most people. However, without adequate compensation, the movements of the body during walking could impair vision. Previous research has shown how the eyes, head and trunk movements are coordinated to provide the compensation necessary for clear vision, but the overall effectiveness of these coordinated movements is unknown. The goal of the research presented here was to provide a direct measure of visual performance during locomotion, while also investigating the degree to which coordinated head and body movements can be altered to facilitate the goal of seeing clearly.

Methods: To measure visual acuity, subjects identified the orientation of the "gap" in sequentially-presented Landolt Ring optotypes. The size of the optotypes varied according to the subject's success rate until the threshold was determined. Walking acuity was compared to a standing measure obtained in the same way. Far (4.0 m) and near (0.5 m) walking acuity was compared in Study 1. In a second study, the near condition was repeated at five walking velocities ranging from 1.0 up to the 1.8 m/s used in Study 1. In a third study, the optotype presentation was constrained to occur either AT or BETWEEN heel strikes during far target viewing. A measure of distance between the subject and a theoretical point in space where the visual fixation of the point would require a minimal amount of eye movement was calculated using motion analysis data. This head fixation distance (HFD) was used to quantify the collective effects of changes in the non-ocular body movements on the visual fixation goal.

Results: Visual acuity was not affected by walking during the far target condition in Study 1. However, despite a change in HFD that is consistent with a reorganization of body movements that reduce the magnitude of the required eye movements, a measurable decrement in acuity was observed for the near condition. Acuity improved systematically as the walking velocity was reduced during Study 2, but decrement in acuity was present during near viewing even at the slowest walking speed. Results from Study 1 showed that walking acuity is equivalent to standing acuity for far viewing distances. However, Study 3 showed that acuity is not consistent across the step cycle with a measurable decrement observed AT heel strike when compared to BETWEEN heel strike presentations.

Discussion: Facilitated by coordinated movements of the head and body, visual acuity of far objects is maintained while walking. However, these mechanisms, in conjunction with the associated eye movements, are not able to fully compensate for near target fixation and heel strike perturbations. The direct measure of walking acuity demonstrated may be a useful for diagnosing abnormal gaze stabilization mechanisms and quantifying their functional consequences.